Speak Less, Hear Enough: On Dynamic Announcement Intervals in Wireless On-demand Networks

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Announcement protocols

Network protocols relying on broadcasting announcements:

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- Service Discovery: *Bonjour / ZeroConf*
- Routing Protocols: *RIP, OLSR*
- Delay-tolerant Networking (DTN): *Forban, Serval*

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Bandwidth in wireless networks (802.11, Bluetooth) is limited.

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- **Epidemic routing** to as many neighbors as possible.
- Static nodes (*islands*):
  - people trapped in houses, emergency camps, etc.
- Moving nodes (*carrier-pigeons*):
  - by bike, car, foot, etc.

Delay-tolerant data exchange

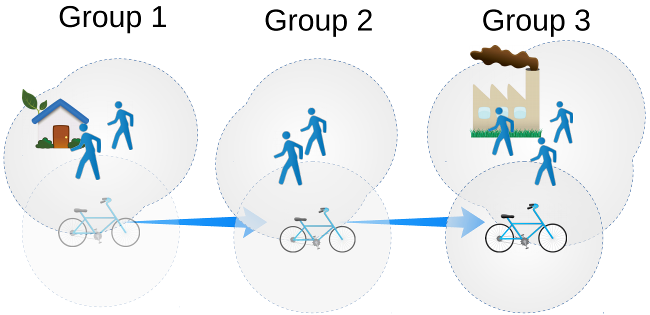

Figure: Drive-by store-and-forward data exchange.

Delay-tolerant data exchange

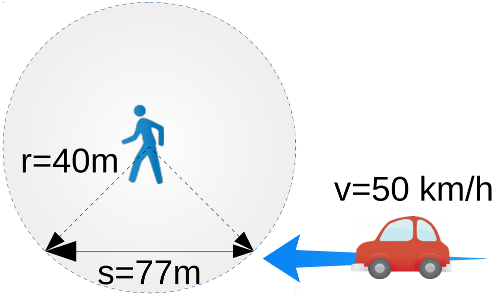

Figure: Drive-by window of opportunity example.

DTN drawbacks

- $r = 40m$: WiFi radius
- $d = 10m$: Node-to-street distance
- $v = 50km/h$: drive-by speed

$\rightarrow$ under 6 seconds for node discovery and exchange of data.

High announcement rates: **more** power consumed,
low announcement rates: data exchange **time reduced**.

Basic idea

Regular static announcements:
Announce myself to the other nodes within a **fixed time delay**.

Dynamic announcements:
Adapt announcement rate **dynamically**, based on multiple properties.

Interface for announcement computation

Access to a few general purpose variables:

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Announcement interval computation strategies

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8. *Unsteady*: delay derived directly from the **number of nodes**

Implementation constraints

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- 20 seconds used in this paper

Quality measuring properties

Main goal: 1 second global announcement delay

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- *Global Anouncement Rate*: announcements per second
- (*Global Announcement Gaps*: time between two announcements)
- *Adaptation Rate*: time needed to adapt to the new rate

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- *JavaScript*-based API for dynamic announcement computation

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- ***Splitting*** *network*: split into two equally sized networks

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- **Raspberry Pi 3** Model B single-board computers
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- **8 network participants**
- **1 system under test** (SUT)
- Data-logging at 5 Hz using an ***Odroid Smart Power***

Test configurations

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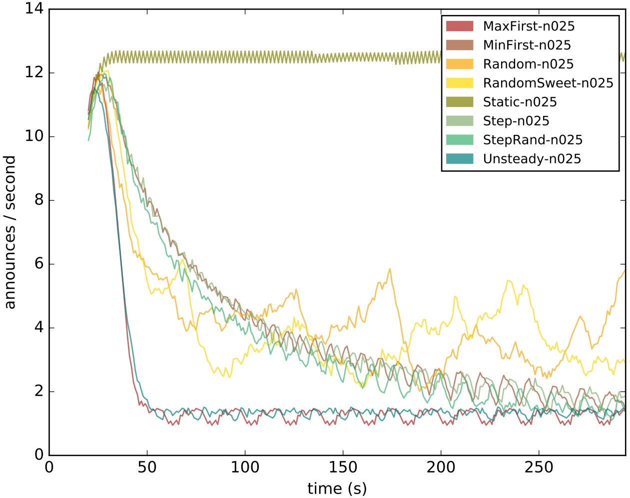
Test configurations

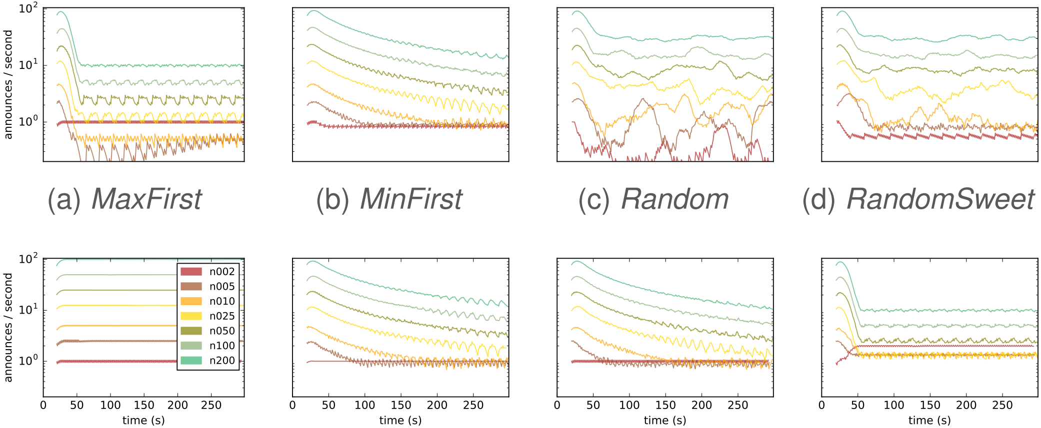
- **Eight** announcement **strategies**
- **Number of nodes**: 2, 5, 10, 25, 50, 100, 200
- **batch** node start, **delayed** node start
- **two dynamic** network configurations: *Split* and *Merge*
- total of **224 independent experiments**

Announcements in a 25 node static network (1)



Announcements in a 25 node static network (2)

All non-random strategies reach the goal of a **less saturated network** and also approach **the same minimum**.



(a) *MaxFirst* (b) *MinFirst* (c) *Random* (d) *RandomSweet*

(e) *Static* (f) *Step* (g) *StepRand* (h) *Unsteady*

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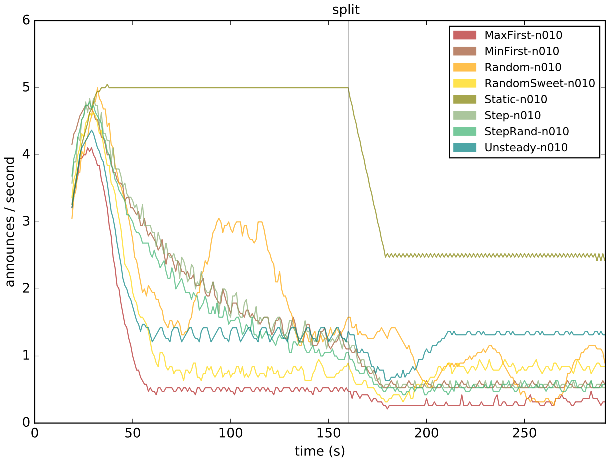
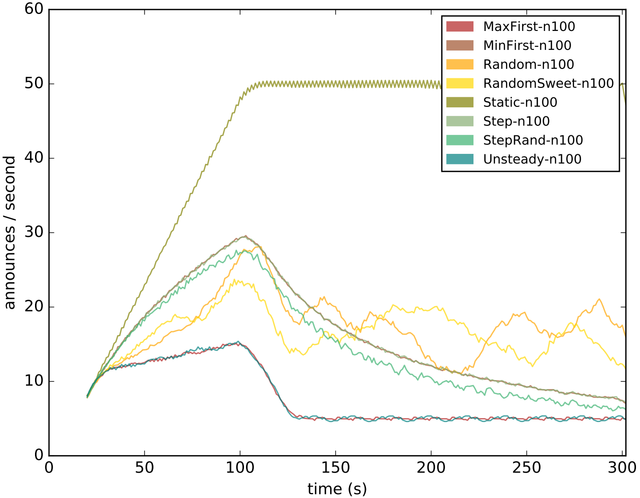
- *Unsteady* and *MaxFirst* show **very high adaptation rates**, since the announcement delay is set after the first observation delay.
- *MaxFirst* achieves a **high** rate in **larger** islands, while *MinFirst* achieves a **higher** adaptation rate in **smaller** islands.
- Adaptation rates of *Step*-based strategies **depend on the number of nodes**.

Adaptation rate: 10 nodes split



Adaptation rate: 100 nodes delayed



Name \ # Nodes	2	5	10	25	50
Static	291	732	1460	3658	7296
Random	34.4%	47.0%	37.0%	37.9%	37.3%
RandSweet	58.1%	41.7%	29.0%	35.6%	37.7%
Step	101.7%	**45.4%**	**35.2%**	**33.2%**	**33.4%**
StepRand	99.7%	42.5%	32.5%	30.1%	30.2%
MaxFirst	99.0%	21.2%	**17.1%**	**17.0%**	**17.1%**
MinFirst	84.9%	44.3%	34.7%	33.3%	33.5%
Unsteady	**188.7%**	56.8%	**32.5%**	**17.7%**	**17.1%**

Table: Bandwidth Comparison

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- *Unsteady* and *MaxFirst*: **bandwidth savings** $>$ **80%**
  $\rightarrow$ quick adaptation to the given situations.
- Unsteady: *188.7%* of *Static* in a two nodes network.
  $\rightarrow$ low announcement delays in small networks achievable.

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$$E := \int_0^{300} P_{measured}(t)\,\mathrm{d}t - 300 * P_{idle}$$

Name	# Ann.	E (mWh)	rel. Ann.	rel. E	ratio
Static	**1323**	**1.99**	1.00	1.00	1.00
Static05	5404	11.97	4.08	6,00	1.47
Static01	**29342**	**32.52**	22.18	16.31	0.74
MaxFirst	**256**	**1.17**	0.19	0.59	3.04
MinFirst	473	1.26	0.36	0.63	3.04
Random	434	1.34	0.33	0.67	2.04
RandomSweet	**342**	**0.73**	0.26	0.37	1.42
Step	495	1.20	0.37	0.60	1.61
StepRand	460	1.12	0.35	0.56	1.61
Unsteady	**514**	**1.38**	0.39	0.69	1.78

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- correlation coefficient $r = 0.985$
- **Side-effects** due to programming language, OS, ...
- though relatively small, **announcements effect battery lifetimes**

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- **Eight different announcement strategies** compared
- **reduction by 80%** compared to a static strategy, while reaching the goal of a fast island discovery.
- **Energy impact**: announcements effect battery lifetimes and are **worth to be reduced**.

Future Work

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- *Make software use dynamic announcements.*

The final Slide

Thanks for your Attention!

Are there any questions?